Building and Using the Stream Table

Introduction

An understanding of how sediment, vegetation and flowing water interact to form stream channels is essential in knowing how to restore and manage them. Because it is impractical or impossible to directly observe these processes in real streams, a portable model stream has been developed by the Missouri Department of Conservation. The model contains moveable "sediment" that responds to flowing water much like sediment in a real stream. This model accurately portrays stream processes like bank erosion and headcutting.

This model stream is particularly useful because most observers, regardless of their age or background, can understand fairly complex concepts demonstrated by the model that are otherwise difficult to comprehend, e.g. illustrating a destructive practice like channelization. The model also effectively convinces audiences that protecting or restoring stream corridor vegetation is the best way to protect both property and fish and wildlife values. Within the model, fluvial processes like bank erosion and point bar formation take place rapidly, so these processes can be observed in a short period of time. Regardless of their interest in stream conservation, most people are fascinated by the model.

The model stream described here is the product of considerable development experience. Essentially, the model stream consists of a box filled with sediment. The box is supported by jackstands, and a small battery-powered pump circulates water through it. To portray a reasonable range of fluvial processes, a model stream should be large enough to contain at least three stream bends. Within this constraint, the model described here has been made small, light, inexpensive and easy to build. The floor of the box containing the model stream, for example, is made from a prefabricated hollow-core door, and most other materials needed for its construction are locally obtainable.

These instructions provide a general guide for building and using a model stream to educate both lay and professional audiences.

Using the Model Stream

Figure 1 shows a complete model stream. The model consists of a box filled with granulated plastic and is supported by four adjustable jackstands. A small reservoir at the lower end of the

box contains a 12-volt battery-powered bilge pump that sends water from this reservoir through a hose and back to the upper end of the box.

Begin by setting up the model as shown in Figure 1. Use a carpenter's level to make sure the box is level from side to side. Adjust the jackstands so that the box is slightly sloped from the inlet toward the drain. Use the level as shown and start with a slope of about 3/4 inch drop per 24 inches of length. After doing this, fill the box with granulated plastic to within an inch or so of the top. Fill the reservoir with water and start the pump.

The model is typically set up for a demonstration by excavating a small channel with three complete meanders (Figure 2). Try to put plenty of relief in the surface of the granulated plastic. As the eroding bends in the stream cut into these hills, spectacular "slumps" will occur. After making this channel, adjust the flow to a rate which causes some erosion but not so much that the channel will be decimated before your presentation. It's best to start slow and gradually increase the flow. Allow the stream to run for a few minutes before your presentation. This will give it time to develop its own channel characteristics. The small bilge pump used in this model will pump some sediment, but will jam if too much gets into it (this is why it is mounted above the bottom of the bucket--allowing some plastic to accumulate there before the pump begins to pick it up).

Making a Stable Bend to Demonstrate Channel Stability

When you are satisfied the channel you have made is working well (bends will be gradually eroding), put a "tree revetment" in the first (farthest upstream) bend. This is done by placing small sprigs of fresh red cedar (which closely resembles an entire tree in shape) along the lower portion of the bank in overlapping arrangement (Figure 2). This will be your "stable" bend. Once you get this bend stabilized, leave it alone! If you increase the flow of water in the box for a couple of minutes (to simulate a flood), this bend will form a point bar, backwater, scour holes and other features characteristic of a natural, healthy stream. Don't manually move sediment around in this bend though--just as in a real stream, disturbance will destroy these features. You'll use the bends below the revetted reach to demonstrate the effects of devegetation and disturbance.

Tell your audience that this bend simulates either a revetted bend or a naturally vegetated bend. Point out its characteristics: deep holes adjacent to the cedar sprigs, a stable point bar, a backwater, and very limited bank erosion. Contrast this bend with the relatively wide, shallow, unstable bends below it. Note that the unprotected banks are constantly eroding and that their beds are also unstable. This reach is often characterized by multiple, shifting channels. Relate these characteristics to landowner's concerns (rapid bank erosion and loss of farmland) and to fish habitat values. You may want to focus on fish habitat diversity and channel stability. The substrate in the unstable reach will be constantly shifting. This is the habitat for animals and plants that inhabit the stream bottom. Relative to the "stable" bends, it will lack diversity. The stable bend will have a wide range of depths, current velocities, and substrate sizes. Usually, a small backwater area will form on the downstream side of the point bar in this reach. In real streams, these areas are important to small fish (as "nursery" areas) and to aquatic invertebrates, especially when they are filled with emergent aquatic vegetation. Note that such vegetation can only grow on stable bars.

Demonstrating Stream Response to Channelization

The model is an excellent tool for showing the effects of channelization (or stream straightening). Start by giving a typical rationale for channelization: that a landowner is losing land to bank erosion and believes that the "bends in the river" are the cause of bank erosion. Proceed as shown in Figure 2 and excavate a new channel, working upstream. Place a scoop of fill in the upstream end of the bend to be cut off by the channelization. Before removing the last scoop of plastic from the new channel, be sure to draw the audience's attention to the stream. As you open the new channel, water will rush through it at a velocity that is obviously much higher than in the old (now dry) bend. The banks in the channelized reach will immediately begin to erode and, after 30 seconds or so, it will become obvious that the stream is beginning to establish meanders in the channelized reach. Slugs of sediment will be sent downstream and downcutting (erosion of the stream bottom) will proceed upstream of the channelized reach. Downcutting that is moving in an upstream direction is called headcutting. If you closely observe the reach upstream of the channelization, you'll see evidence of this downcutting as small terraces will form and be left high and dry as the channel is lowered. In some cases, this headcutting will destroy or degrade the stable reach. Backwater areas, for example, may be left dry as the channel downcuts.

Demonstrating Headcutting

In real streams, headcutting can be caused by streambed (or "base level") lowering that results from gravel removal, dredging, or channelization. To demonstrate the effects of gravel removal, use a scoop to remove sediment from the channel at one of the "unstable" bends. As you remove sediment, headcutting should become apparent upstream. **This demonstration will not work well if bed load movement is high because of a previous disturbance to the stream (e.g. a channelization demonstration).**

Base level lowering can also be demonstrated by lowering the adjustable gate at the lower end of the box. If the gate is lowered a half inch or so, a visible headcut will travel upstream. This demonstrates how a lowering of base level can cause headcutting in an entire basin. Radical headcutting like this might occur, for example, in tributaries of a stream that has been extensively channelized.

Demonstrating the Effects of Debris in Streams

The effects of large debris--either boulders or trees that have fallen into streams--can be demonstrated with the model stream. Place a small cedar sprig or rock into the channel; the lower part of the "stable" reach is probably best for this demonstration. You'll see a scour hole form upstream and immediately downstream of the obstruction. Deposition tends to occur further downstream, in the "shadow" of the object. Boulders and large trees in stream channels tend to have the same effect, and the diversity and cover they provide are important elements of aquatic habitat.

Notes on Use of the Model Stream

Use of Granulated Plastic in the Model Stream

Most people will assume that the material used in the model is coarse sand, although many will ask what it is. When told it is granulated plastic they usually wonder why natural sand and gravel aren't used instead. Although the model channel's relative dimensions closely approximate those of a natural stream, its overall size is much smaller. While average current velocity in a small Ozarkian stream in flood might be around 3 feet per second, average current velocity in the model stream's channel, because of its smaller size, will never exceed about 0.5 feet per second. Thus, to achieve a realistic response in the model, the sediment in it must have a lower density than that of rock--the low velocities in the model stream are inadequate to transport find sand, let alone gravel. The plastic has another characteristic that makes it work well--its angularity makes it hold a slope well, i.e. it has a high angle of repose. This property makes features in the model stream, e.g. cutbanks, bars and headcuts, visually distinctive. Stream features are further distinguished as plastic particles of different sizes and color are deposited in different parts of the channel--this is why a mixture of sizes and colors are used in the model.

Maintenance of the Pump and Reservoir System

The filter bucket within the model's reservoir is designed to keep plastic from getting into the bilge pump. As it accumulates particles, it should be removed and emptied into the stream box. While doing this, you can momentarily place your hand over the drain hole in the box to prevent plastic from getting into the reservoir. If plastic gets into the bilge pump, it may jam. If this happens, you can clear the pump by snapping it apart--its base will come off if the two small plastic ears which hold it together are compressed. This will allow you to clear plastic from the pump. If the pump runs too long while clogged with plastic, it may burn out. For this reason, it is a good idea to keep an eye on the inlet at the top of the box. If the flow of water stops, check to see if the pump is clogged.

Indoor Use of the Model Stream

The model stream can be used indoors on waterproof floors (e.g. concrete or linoleum). Keep paper towels or a mop handy for small spills and be sure to place squares of plywood or thick cardboard under the jackstands to prevent damage to the floor.

When the model stream is fully charged with water, the total volume of water in the system (in the box and within the reservoir) will be greater than that of the reservoir. If the pump is stopped, the reservoir will overflow as this water drains from the box. Outdoors, this will usually cause no problems. When using the stream indoors, however, you must remove water from the system after the pump is stopped or set the reservoir inside a larger container that will catch the overflow. If a spill would cause problems (e.g. ruin the floor), it is a good idea to have buckets at hand to remove water if the pump system should fail!

Safety Note

Don't use a 12-volt transformer and household current to power the bilge pump. Don't operate the model with a battery charger attached to the battery. **Operate the model only with a 12-volt battery.** Operation of the model with other than a 12-volt battery could result in serious injury.

Equipment Checklist

The day before your demonstration, use the following list to make sure you have everything you'll need:

______ stream box
______ granulated plastic
______ 4 jacks
______ 12-volt battery, **fully charged**
______ reservoir bucket with attached plumbing and filter bucket
______ large tub(s) for carrying plastic and/or water
______ grain scoops
______ freshly cut cedar sprigs and pruning shears
______ carpenter's level
______ handout literature
______ this manual

For indoor use, you'll also need:

______ paper towels, towels, and/or a mop
______ small squares of plywood or heavy cardboard to place under the jackstands

Model Stream Materials List

Total cost is about $200 (total cost does not include granulated plastic)

______ 1 36" x 6'8" unfinished interior hollow core door. Be sure to get a door with square edges (some are beveled) -- and <u>without</u> a hole drilled for the doorknob.

______ 3 8'1" x 6" #2 pine boards or equivalent. These board **must** be sound -- any loose knots or cracks will allow leaks when the box is in use.

______ 1 24" length of 2" aluminum angle (for stream box corners)

______ 1 cartridge caulking type liquid glue

______ 1 pound #6 x 2" dry wall screws

______ 24 #6 x 3/4" flat head wood screws (to secure aluminum corners to box)

______ 1 2" inside diameter PVC union joint, modified as shown in Figure 1

______ 1 5" length of 2" PVC pipe

______ 1 10 gallon plastic feed tub (for reservoir)

______ 1 3 gallon heavy duty bucket (for filter bucket)

______ 1 Large plastic feed tub for carrying wet plastic or water

______ 1 marine 12-volt bilge pump rated at 360 gallons per hour

______ 1 5/8" poly connector, barbed at both ends (for removable connection between reservoir and stream box)

NOTE: You may use larger diameter tubing for the model--just be sure that all fittings are sized accordingly.

______ 2 5/8" poly connectors, barbed at one end, threaded to fit valves at other end

______ 2 5/8" poly connectors, right angle elbows

______ 1 3/4" water valves (ball-type valves are much less prone to clogging than gate valves)

______ 12 5/8" pipe straps

______ 20 1/4" x 3/4" bolts, nuts, and washers for attaching hardware to reservoir bucket

______ 14 feet of 5/8" clear plastic tubing

______ 4 square feet of window screening

______ 1 6' length of 16 gauge, 2 conductor double insulated wire for power cord running from bilge pump to battery

______ 1 pair 10 or 25 amp alligator clips

______ 4 automotive jack stands. Two of these should be the notched type, which allow find adjustment of box slope. Alternately, small wood shims can be used to adjust elevation.

______ 1 gallon polyurethane paint

______ 1 cartridge of clear silicone sealant

______ 2 plastic grain scoops for moving plastic (these are available at farm supply stores)

______ 5 appropriate waterproof containers for hauling wet plastic

______ 1 12-volt deep cycle marine lead-acid battery. Get the smallest one you can find--ours has an 8" x 5" footprint and will run the pump for an entire day. You will need access to a charger for the battery.

______ 200 pounds granulated plastic

150 pounds	16/20 grit size
20 pounds	12/16 grit size
30 pounds	20/30 grit size

Cost of plastic is $1.75 per pound.

Supplier: Composition Materials Inc.
125 Olgate Lane
Milord, Connecticut 06460
Tel (800)262-7763 or (203)874-6500
Fax (203)874-6505
info@compomat.com
Attention: Doug Berkowitz

Crushed walnut hulls can be substituted for granulated plastic, however, walnut hulls must be dried after use, require more time for set up and do not show sediment as good as the plastic. Walnut hull dryers can be built at an additional cost of $250.00. The only known current source for walnut shells is Hammons Products Company, 217 Hammons Drive, Stockton, Missouri 65785, or telephone (417)276-5181. These sizes should be obtained and mixed to the ratio shown:

particle size		approx. amount
20/30	(fine)	40 pounds
12/20	(medium)	150 pounds
8/12	(coarse)	10 pounds

If you are on a tight budget, you may omit the coarse (8/12) fraction. The shells are sold only in total increments of 50 pounds.

(Refer to Figure 1)

1. Make sure that the side of the door you choose to be the interior of the box is smooth. Sand if necessary.
2. Cut two sections of 1" x 6" to fit flush with the ends of the door. Sand these smooth.
3. Cut two sections of 1" x 6" to form the box sides. Make the sections 1 ½" longer than the door so they will join the two end sections correctly. The box must be carefully built so that it will be waterproof when finished.
4. Pre-drive all screws through one of the short (end) sections of 1" x 6" so that they

protrude about 1/4" from the side to be joined with the door--these protruding points will hold it in place and prevent slipping (on the glue) as you drive the screws into the door. The screws should be placed about 1" from the bottom of the 1" x 6" and about 5" apart. An electric drill is very handy for driving the screws. You should drill small pilot holes to prevent the 1 x 6 from splitting.

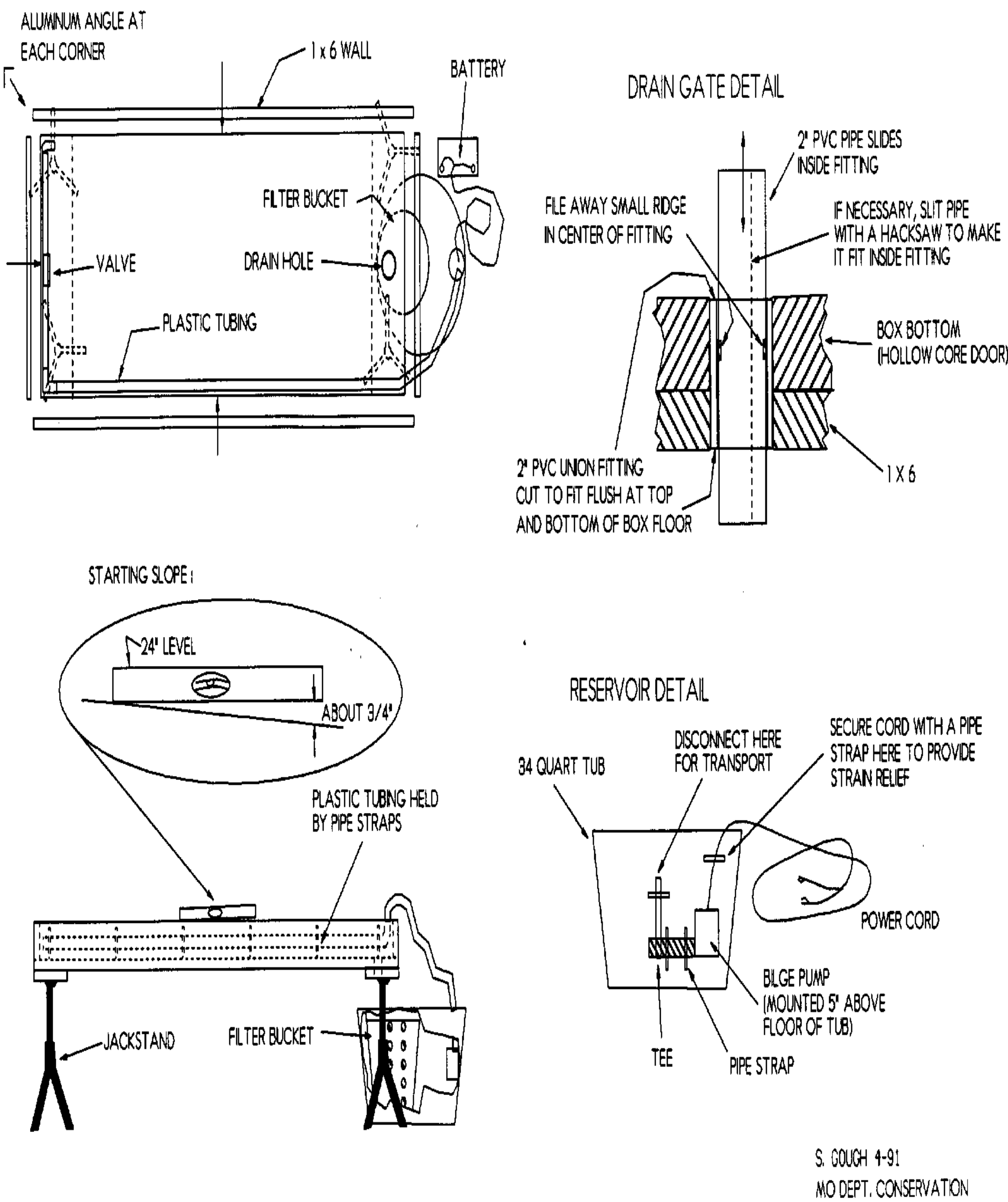
5. Apply glue (caulking type liquid glue) generously to one end of the door.
6. Square one 1" x 6" end section and attach to the door and drive screws.
7. Repeat step 5 at the other end of the door.
8. Run your finger along the seam between the 1" x 6"'s and the door to smooth the extruded glue -- make sure all gaps are filled so that the box is waterproof when finished.
9. Attach 1" x 6"'s that form the box sides using the same procedures as for the ends.
10. Cut sections of 2" aluminum angle to cover and protect joints at box corners. File rough edges and attach using 3/4" flathead wood screws. Countersink the screws into the aluminum (or use round headed wood screws). Fill any gaps in the joint between the box sides and ends with glue before attaching the aluminum angle.
11. Turn the table over and cut two sections of 1" x 6" to form the end reinforcements for the box bottom (the jack stands bear against these sections). Glue and screw these to the box bottom.
12. Turn the box over, and using a 2" hole saw, drill the drain hole. The hole should pas through one of the 1" x 6"'s attached in the last step. After modifying the 2" PVC union joint as shown in Figure 1, glue it into this hole. You may have to use a wood rasp to enlarge the hole before doing this.
13. Apply at least 3 coats of paint to the box.

Instructions for Building Pump and Reservoir System

(Refer to Figure 1)

1. Mount bilge pump to the inside and about 5" above the bottom of the reservoir bucket.
2. Cut an 8" section of plastic tubing and attach to the pump. Attach an elbow fitting to the other end.
3. Secure this assembly to the side of the reservoir bucket as shown. Use silicone sealant to waterproof all holes drilled in the bucket.
4. Drill several ½" holes in the side of the filter bucket.
5. Cut a square of window screening that is large enough to cover all the holes. Glue and pop-rivet it in place inside the bucket using lots of silicone sealant.
6. Cut about 11 feet of plastic tubing. This section runs from the reservoir bucket to the box and up to a valve to deliver water to the upper end of the stream box. Using pipe straps, attach this section to one side of the box. Using the remaining plastic valve, 5/8" adapters, 5/8" elbow joints and pipe straps, complete this assembly as shown in Figure 1.

FIGURE 1. MODEL STREAM CONSTRUCTION AND SETUP
(NO SCALE)



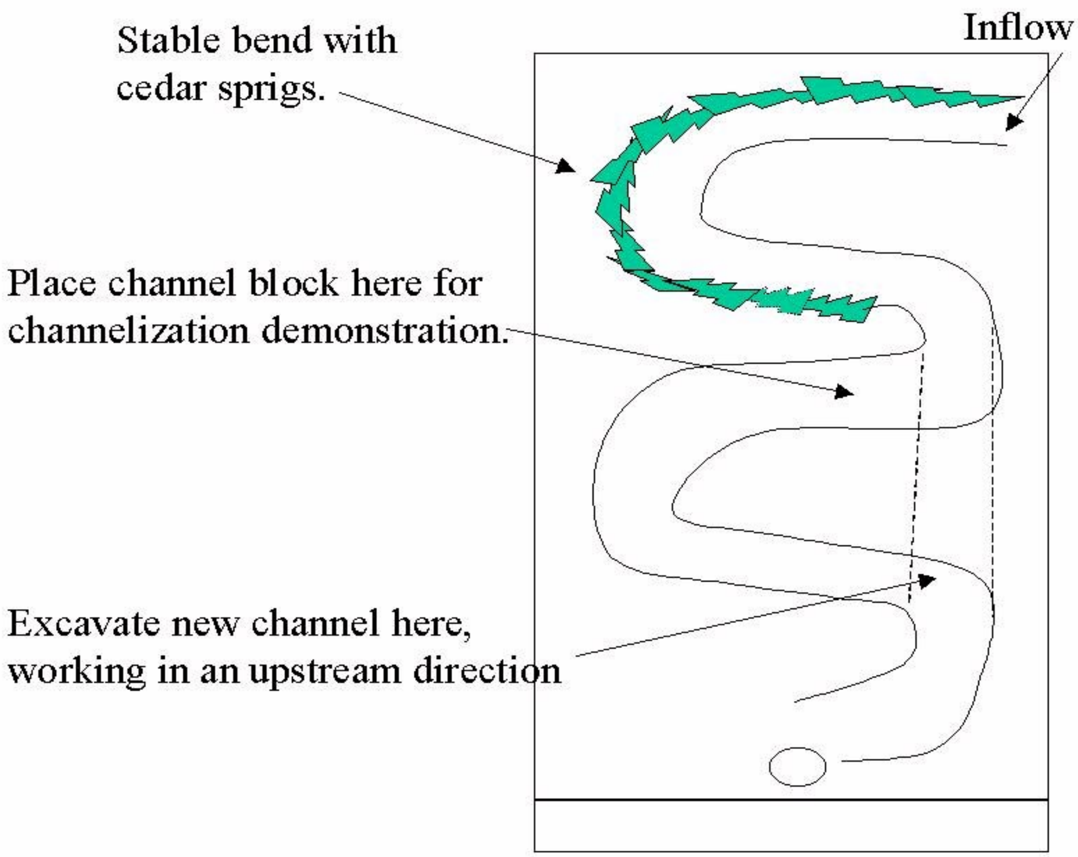


Figure 2. Placement of stable bend and channelization demonstration on the model stream.